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READING COURSES IN IRRIGATION

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The statement made by Thaer, the noted leader in agricultural science in Germany nearly a century ago, that: "*An agriculture which has mastered the control of water so that moisture can be supplied to the soil or removed from it at will, instead of being left to chance, has reached the highest possible degree of perfection,*" has far greater significance to-day than it had when uttered; and no more convincing evidence of its truth can be found than is furnished by the irrigated lands of California, where the benefits of putting water on the land by irrigation and the evils of not removing the surplus by drainage are alike conspicuous.

The area of land irrigated is now being rapidly extended, and there is every reason to believe that the rate of this extension will become greater in the future. There are several million acres of land susceptible of irrigation, and the water to irrigate it is now running to waste. Its productive capacity and selling value would be quadrupled if "*moisture can be supplied at will, instead of being left to chance,*" and the rising values of both land and water will now permit of the expenditure to do this.

Each new area brought under irrigation, each new increase in the water taken from streams or lifted from under-ground supplies, gives rise to new questions regarding water titles and adds to the importance of canal management. Hence, while our knowledge of irrigation is constantly extending, we are also constantly being confronted with new problems which have to be solved. Those most familiar with irrigation and most skilled in its practice find in its changing conditions a constant field for study, while beginners find that the difference

between irrigated agriculture and agriculture dependent on rainfall requires of them a knowledge of many things wholly new and strange.

A large percentage of the lands being brought under irrigation are being settled by men from humid sections of the country who must learn in some way how to grade their fields, how to lay out laterals, how much water is needed, and how often to use it. California is vitally interested in these farmers becoming skillful users of water in the shortest possible time. Too much water is almost as bad as too little. Wasteful use by one irrigator often ruins his neighbor's crop and injures his own. The injury from alkali is chiefly due to wasteful or unskillful use of water.

It is believed that the University of California can aid in the general improvement of irrigation practice by extending the work now being done in the class-room. This includes instruction in Irrigation Engineering, Irrigation Institutions, and Irrigation Practice. We have decided to offer reading courses in Irrigation Institutions and Irrigation Practice. Under Irrigation Institutions are included the business and financial methods under which canals are built, how the rights to the water which fills them are acquired, and the conditions and terms on which irrigators are supplied. Irrigation Practice will include descriptions of the methods of preparing land for irrigation, the cost of such preparation, the results of measurements to determine the amount of water used in irrigation and the factors which influence it, and description of the methods of irrigation employed in California, for fruit growing, fields, and gardens.

Those desiring to enroll themselves as readers should make application to W. T. Clarke, Assistant Superintendent, University Extension in Agriculture, Berkeley, California. Each reader will be furnished with a text-book in the branch of the subject which he desires to study. He will be expected to make himself thoroughly familiar with its contents. A circulating library is also provided for collateral reading and reference. These books should be read as carefully as possible, in accordance with the directions given in this circular. After the completion of the work here outlined, an examination will be arranged with some one connected with the Department of Irrigation Institutions and Practice.

These courses may be considered a University course given *in absentia*, and must be pursued with the same care and thoroughness as though done in the class-room in Berkeley. The names of those completing these courses will be kept as a special mailing list; and they

will receive thereafter, not only the bulletins of the Experiment Station, but all circulars and notices of special publications on irrigation issued by the United States Department of Agriculture. Those reading in these courses by themselves will receive the books forming the reference library, one at a time, by express, and will be required to pay the express charges both ways. There will be no fees or other charges to be paid by the students, except for damage to books beyond reasonable wear. The Irrigation Department will attempt to answer letters of inquiry of readers in this course, and to assist them in any questions they may find in their studies.

Reading Circle.—It is strongly recommended that wherever possible a reading circle be formed for mutual helpfulness in this study. Where this is done, the whole reference library will be sent to the member designated by the circle, and the distribution can be arranged to suit the convenience of the members. We would suggest that the circle form an organization, changing a sum for membership sufficient to raise a fund not only to pay the express charges on the circulating library, but also to buy a few books on the subject for the local library or as a nucleus for a public library, if one is not already in existence in the community. Thus the work of the circle will become more permanent.

Another advantage of the organization of a reading circle will be the possibility of personal instruction by a visit, to the community, of a member of the staff of the Irrigation Department. Where possible, some such arrangement as the following will be made: After the completion of the course by the circle, a date will be arranged for this visit; and if provision can be made for the projection of pictures on a screen, the instructor will come prepared to give an illustrated lecture comparing California's irrigation methods with those of other countries. The instructor will also come prepared to give a day to considering with his class the local problems of interest or importance.

Those who enroll as students will be expected to make reports of their progress, and in these reports to bring out the relation of what they are reading to local conditions or practice. This will aid the instructor in making suggestions as to further studies. Comparisons by the reader of local practice or local problems with the description and discussion of the text will give life and interest to the work. In addition the reader should seek to arrive at independent conclusions as to both the institutions and practice needed to secure the best development of irrigated agriculture in his section. To this end it is sug-

gested that each reader prepare at the beginning of his course a set of questions which embrace the things of greatest interest to him personally. The following list is suggestive of what these may embrace:—

IRRIGATION PRACTICE.

1. Is check irrigation suited to mixed farming and rotation of crops?
2. What plan of applying water in irrigation is adapted to the largest number of crops, and hence to the adoption of a rotation system?
3. Which is better suited to the irrigation of orchards, checks or furrows?
4. How often should orchards be irrigated?
5. How often should alfalfa be irrigated, and when?
6. Does it pay to irrigate small grain?
7. What are the benefits of winter irrigation, and can crops be grown by winter irrigation alone?
8. Is seepage water or alkali a menace?
9. If so, when do its ill effects begin to be manifest, and what are the causes?
10. Is complete under-drainage feasible? If so, at what depth should the drains be laid?

IRRIGATION INSTITUTIONS.

1. What is the proper foundation for water titles—riparian rights, appropriations, or licenses issued by the State?
2. Should water rights for irrigation be attached to the land irrigated?
3. Should there be an official State record of water titles?
4. Should charges for water be based on the acres irrigated, or on the quantity of water used?
5. Which are more efficiently managed—canals operated by water companies, or canals operated by farmers?
6. What is the most convenient unit of volume for the delivery of water—the inch, the cubic foot per second, the gallon, or the acre foot?
7. What volume of water will give the best return from an acre of land? What volume will give the highest return from the acre foot of water?
8. What is the better practice in irrigation—to apply water with the object of securing the largest return from the land, or the best return from a unit volume of water?
9. What is the value of water for winter irrigation? What is its value for summer irrigation?

The books included in this course bring together the results of practical experience and scientific observation in widely separated sections of the country, and it is believed will aid in determining what is best suited to the widely varying conditions of this State. It is also hoped that it will contribute to bringing about a clearer understanding

of the complex and important water problems of California which have been created by the increasing needs of users for irrigation, the growing consumption of water by cities and towns, and its augmented value for power purposes. The protection of existing rights, the adjustment of rival and conflicting claims of the different classes of users, and the wise direction of future development, make the management of the water resources of California its most important industrial issue.

INSTRUCTION IN IRRIGATION AT BERKELEY.

For the information of those who desire to continue their studies in Irrigation at the University, it may be stated that a complete course in Irrigation Engineering is given. The courses given by the Department of Irrigation and the courses in the College of Agriculture most directly related to Irrigation are as follows:—

1. Irrigation Institutions and Economics.

Professor MEAD.

Present conditions of irrigation in the United States; irrigation legislation; methods of establishing rights to water; inter-state problems; conditions necessary to development of the agricultural resources of the arid West; comparisons of irrigation methods and laws of other lands with those of the United States; irrigation in humid sections of the United States; operation of irrigation works, individual, coöperative and corporate enterprises; national irrigation; water right contracts; duty of water. Lectures and recitations.

2. The Diversion, Conveyance, and Application of Water.

Professor ETCHEVERRY.

Properties of water; units of measurement; flow of water through orifices, over weirs and in open and closed channels; gauging laterals, canals, and streams by means of floats, current meters, weirs, modules; irrigation works classified; diversion weirs and headgates; alignment, slope and cross-section of canals; suitable grades for required velocities; construction and maintenance of canals; flumes and pipes for irrigation, their construction and use; methods of applying water to land; duty of water. Full illustrations by lectures and practical problems.

2A. Irrigation Design.

Professor ETCHEVERRY.

The design of irrigation structures, such as headgates, flumes, and drops. Preparation of detailed estimates of cost of such structures.

3. The Conservation of the Water Supplies.

Professor ETCHEVERRY.

Sources of water supply; precipitation, run-off and fluctuation in stream-flow; loss of water by evaporation and seepage; return waters; removal of surplus and seepage waters; reclamation of alkali lands by means of drainage;

storage of water in natural lakes and artificial reservoirs; utilization of subterranean sources of supply by means of pumps, drains, tunnels; conservation of soil moisture; influence of forests on water supply.

4. **Drainage.**

Professor ETCHEVERRY.

Structure of soil and its relation to drainage; necessity for drainage; its effects on the soil; ground water and its flow; laying out drains; distance between; depth of, grade of; size of tile; kinds of drains; drainage systems and districts; estimates of cost.

AGRICULTURE.

1B. **Chemistry and Physics of Soils.**

Professor HILGARD and Assistant Professor LOUGHRIDGE.

Origin, formation, and classification of soils. Physical properties and mechanical analysis; chemical composition. Soil analysis—its methods, utility, and interpretation. Policy of culture; exhaustion of soils and their fertilization and restoration; drainage, irrigation, soils of the arid and humid regions; soil regions of the Pacific coast.

4A. **Agriculture.**

Professor WICKSON.

Field cultures of grains, vegetables, and forage plants.

4B. **Horticulture.**

Professor WICKSON.

Principles and practice of fruit growing in semi-tropical countries, with special reference to California conditions and methods.

SUGGESTIONS FOR READERS IN IRRIGATION COURSES.

IRRIGATION PRACTICE.

Volume 1.—Text-book.

Volume 2.—Collateral reading: King on Irrigation and Drainage.

The text-book in Irrigation Practice is made up from a series of bulletins, the larger part of which were prepared by members of the station staff or professors in the University of California.

It begins with a description of the methods and tools used in preparing land for irrigation and the methods of applying water to crops. This is followed by a description of some of the home-made devices by which farmers can lay out their own laterals.

Next comes a discussion of irrigation practice with special relation to conditions in California, and includes irrigation in field and garden, irrigation in fruit growing, and the results of the irrigation of orchards on the Pacific coast. This portion of the text will give an understanding of the principles which underlie irrigation practice in California, so far as the preparation of land and application of water are con-

cerned. The reader is then prepared to take up the study of the special methods and practices employed in different parts of the State. Those given are from the Southern and Central portions of California.

The summary of investigations of the amount of water used throughout the United States, which follows, is intended to aid the reader in reaching a conclusion as to the area which can be served by the water supply of his section. The concluding pages of the bulletin deal with some of the evils of irrigation and the methods by which they may be overcome. The two chief evils—the swamping-up of the lower lands of the irrigated territory, and the accumulation of alkali in the surface soil—both have their origin in seepage waters. This is followed by the results of some of the alkali and drainage studies made in the State.

As collateral reading for the text-book, Chapter III, King's work on Irrigation and Drainage, published by Macmillan & Co., pages 131 to 170 and pages 269 to 289, may be read with profit.

IRRIGATION INSTITUTIONS.

Volume 1.—Text-book: Irrigation Institutions, by Mead, published by Macmillan & Co.

Volume 2.—A Report on Irrigation in California, published by the Office of Experiment Stations, United States Department of Agriculture.

Volume 3.—Canal and Stream Management.

The course in Irrigation Institutions is intended to give an understanding of the legal and economic principles which govern the management of streams and the distribution of water from canals in the states where irrigation has assumed large importance. The text gives an outline of the evolution of these laws and customs.

Volume 2 describes the conditions prevailing in some of the valleys of California. Volume 3 gives some examples of canal management in a number of the Rocky Mountain states, and follows this with a description of the methods for acquiring rights from streams and the division of water between those holding these rights.

For information concerning Instruction in Irrigation at the University of California, address B. A. Etcheverry, Assistant Professor of Irrigation, Berkeley, California.

For information concerning reading courses in Irrigation, address Mr. W. T. Clarke, Department of University Extension in Agriculture, Berkeley, California.

